

In re Application of: Gil ZWIRN et al.
Serial No.: 10/585,376
Filed: January 31, 2008
Office Action Mailing Date: April 14, 2009

Examiner: Jose L. COUSO
Group Art Unit: 2624
Attorney Docket: 32187

In the Claims:

1. (Currently Amended) A method of improving an image by transforming an intensity histogram thereof, the method being performed by a data processor and comprising:

- (a) fitting the intensity histogram to a sum of a plurality of localized functions;
- (b) using said plurality of localized functions to define a plurality of localized intensity histograms;
- (c) for each localized intensity histogram, performing at least one image enhancement procedure, thereby providing a plurality of improved localized intensity histograms; and
- (d) combining said plurality of improved localized intensity histograms, thereby transforming the intensity histogram of the image.

2. (Cancelled)

3. (Original) The method of claim 1, wherein each localized intensity histogram of said plurality of localized intensity histograms is characterized by an intensity range having a minimal intensity value and a maximal intensity value, such that at least one of said minimal and maximal intensity values coincides with an intersection point between two localized function of said plurality of localized functions.

4. (Original) The method of claim 1, wherein said plurality of localized functions comprises a first localized function, a second localized function and a third localized function, and further wherein said plurality of localized histograms comprises a first localized histogram, a second localized histogram and a third localized histogram.

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5. (Original) The method of claim 1, wherein said at least one image enhancement procedure is selected so as to enlarge a relative portion of a high-intensity region of the intensity histogram.

6-14. (Cancelled)

15. (Original) The method of claim 1, wherein the image is a moving image characterized by a plurality of picture-elements, said moving image being formed of a set of still-images.

16-18. (Cancelled)

19. (Original) The method of claim 15, further comprising calculating, for each picture-element of said plurality of picture-elements, a set-averaged intensity value, thereby providing an average intensity matrix representing said moving image, and using said average intensity matrix to construct the intensity histogram.

20. (Original) The method of claim 19, further comprising removing clutter from the image.

21. (Original) The method of claim 20, wherein said removing said clutter from the image comprises:

calculating a statistical deviation for each picture-element over the set of still-images, thereby providing a statistical deviation matrix having a plurality of matrix-elements; and

determining, for each picture element, whether a respective matrix-element of said average intensity matrix is above a first intensity threshold and whether a respective matrix-element of said statistical deviation matrix is below an additional

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intensity threshold, and if so then marking said picture-element as a clutter picture-element in the image.

22-24. (Cancelled)

25. (Original) The method of claim 21, further comprising outlining at least one region in the image, and assigning to each clutter picture-element an intensity value corresponding to a location of said clutter picture-element relative to said at least one region.

26. (Original) The method of claim 25, wherein said outlining at least one region comprises:

applying a thresholding procedure to said set of still-images in a Boolean manner, so as to construct at least one binary matrix having a plurality of binary-valued matrix-elements; and

for each binary matrix of said at least one binary matrix, clustering said binary matrix, so as to obtain at least one cluster of matrix-elements having a predetermined polarity, and marking picture-elements corresponding to at least a portion of matrix-elements enveloping said at least one cluster as outlining picture-elements;

thereby outlining the at least one region.

27-39. (Cancelled)

40. (Currently Amended) A method of outlining at least one region in a set of images arranged grid-wise in a plurality of picture-elements, each image being represented by a plurality of intensity values over the grid and characterized by an intensity histogram, the method being performed by a data processor and comprising:

(a) calculating a set-averaged intensity value for each picture-element, thereby providing an average intensity matrix having a plurality of matrix-elements,

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and constructing a first intensity histogram characterizing said average intensity matrix;

(b) fitting said first intensity histogram to a sum of a plurality of localized functions, so as to provide at least one intensity threshold, each intensity threshold of said at least one intensity threshold being defined as an intersection point between two localized functions of said plurality of localized functions;

(c) for each intensity threshold of said at least one intensity threshold, applying a thresholding procedure to the set of images in a Boolean manner, so as to construct at least one binary matrix having a plurality of binary-valued matrix-elements; and

(d) for each binary matrix of said at least one binary matrix, clustering said binary matrix, so as to obtain at least one cluster of matrix-elements having a predetermined polarity, and marking picture-elements corresponding to at least a portion of matrix-elements enveloping said at least one cluster as outlining picture-elements;

thereby outlining the at least one region.

41. (Original) The method of claim 40, wherein the set of images forms a moving image.

42-45. (Cancelled)

46. (Original) The method of claim 40, wherein said plurality of localized functions comprises a first localized function, a second localized function and a third localized function.

47. (Original) The method of claim 40, further comprising removing clutter from at least one image of the set of images.

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48. (Original) The method of claim 47, wherein said removing said clutter from the image comprises:

calculating a statistical deviation for each picture-element over the set of still-images, thereby providing a statistical deviation matrix having a plurality of matrix-elements and constructing a second intensity histogram characterizing said statistical deviation matrix;

fitting said second intensity histogram to a second sum of a plurality of localized functions, so as to provide at least one additional intensity threshold, said at least one additional intensity threshold being defined as an intersection point between two localized functions of said second sum; and

determining, for each picture element, whether a respective matrix-element of said average intensity matrix is above said second intensity threshold and whether a respective matrix-element of said statistical deviation matrix is below one of said at least one additional intensity threshold, and if so then marking said picture-element as a clutter picture-element in the image.

49. (Cancelled)

50. (Original) The method of claim 40, further comprising performing at least one morphological operation on said at least one binary matrix.

51. (Original) The method of claim 40, further comprising, for each region of the at least one region, defining an origin of the grid, said origin being defined as a central picture-element of said region.

52-62. (Cancelled)

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63. (Currently Amended) An apparatus for improving an image by transforming an intensity histogram thereof, the apparatus being embodied on a computer-readable medium and comprising:

a fitter, for fitting the intensity histogram to a sum of a plurality of localized functions;

a histogram definer, for defining a plurality of localized intensity histograms using said plurality of localized functions; and

a histogram transformer, supplemented by an algorithm for performing at least one image enhancement procedure, for enhancing each localized intensity histogram, thereby to provide a plurality of improved localized intensity histograms, and combining said plurality of improved localized intensity histograms.

64. (Cancelled)

65. (Original) The apparatus of claim 63, wherein each localized intensity histogram of said plurality of localized intensity histograms is characterized by an intensity range having a minimal intensity value and a maximal intensity value, such that at least one of said minimal and maximal intensity values coincides with an intersection point between two localized function of said plurality of localized functions.

66. (Original) The apparatus of claim 63, wherein said plurality of localized functions comprises a first localized function, a second localized function and a third localized function, and further wherein said plurality of localized histograms comprises a first localized histogram, a second localized histogram and a third localized histogram.

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67. (Original) The apparatus of claim 63, wherein said at least one image enhancement procedure is selected so as to enlarge a relative portion of a high-intensity region of the intensity histogram.

68-76. (Cancelled)

77. (Original) The apparatus of claim 63, wherein the image is a moving image characterized by a plurality of picture-elements, said moving image being formed of a set of still-images.

78-80. (Cancelled)

81. (Original) The apparatus of claim 77, further comprising a histogram constructor for constructing the intensity histogram of the image.

82. (Original) The apparatus of claim 81, wherein said histogram constructor comprises an average calculator, for calculating, for each picture-element of said plurality of picture-elements, a set-averaged intensity value, thereby to provide an average intensity matrix representing said moving image; and to construct the intensity histogram using said average intensity matrix.

83. (Original) The apparatus of claim 81, further comprising a preprocessing unit, for performing at least one preprocessing operation on the set of images.

84. (Original) The apparatus of claim 83, wherein said preprocessing unit is operable to remove clutter from the image.

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85. (Original) The apparatus of claim 84, wherein said preprocessing unit comprises:

a statistical deviation calculator, for each picture-element over the set of still-images, thereby to provide a statistical deviation matrix having a plurality of matrix-elements; and

electronic-calculation functionality for determining, for each picture element, whether a respective matrix-element of said average intensity matrix is above a first intensity threshold and whether a respective matrix-element of said statistical deviation matrix is below an additional intensity threshold, and if so then marking said picture-element as a clutter picture-element in the image.

86-90. (Cancelled)

91. (Original) The apparatus of claim 85, wherein said preprocessing unit further comprises:

an outliner, for outlining at least one region in the image; and

intensity value assigner, for assigning to each clutter picture-element an intensity value corresponding to a location of said clutter picture-element relative to said at least one region.

92. (Original) The apparatus of claim 91, wherein said outliner comprises:

a thresholding unit, for applying a thresholding procedure to said set of still-images in a Boolean manner, such that at least one binary matrix having a plurality of binary-valued matrix-elements is constructed; and

a clustering unit, for clustering each binary matrix of said at least one binary matrix, so as to obtain at least one cluster of matrix-elements having a predetermined polarity, said clustering unit being operable to mark picture-elements corresponding to

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at least a portion of matrix-elements enveloping said at least one cluster as outlining picture-elements.

93-103. (Cancelled)

104. (Currently Amended) An apparatus for outlining at least one region in a set of images arranged grid-wise in a plurality of picture-elements, each image being represented by a plurality of intensity values over the grid and characterized by an intensity histogram, the apparatus being embodied on a computer-readable medium and comprising:

- a histogram constructor, for constructing a first intensity histogram characterizing the set of images;

- a fitter, for fitting said first intensity histogram to a sum of a plurality of localized functions;

- an intensity threshold calculator, for calculating at least one intensity threshold, each intensity threshold of said at least one intensity threshold being defined as an intersection point between two localized functions of said plurality of localized functions;

- a thresholding unit, for applying a thresholding procedure to the set of images in a Boolean manner using each intensity threshold of said at least one intensity threshold, such that at least one binary matrix having a plurality of binary-valued matrix-elements is constructed; and

- a clustering unit, for clustering each binary matrix of said at least one binary matrix, so as to obtain at least one cluster of matrix-elements having a predetermined polarity, said clustering unit being operable to mark picture-elements corresponding to at least a portion of matrix-elements enveloping said at least one cluster as outlining picture-elements.

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105. (Original) The apparatus of claim 104, further comprising an average calculator, for calculating a set-averaged intensity value for each picture-element, thereby to provide an average intensity matrix having a plurality of matrix-elements, wherein said histogram constructor is designed to construct said first intensity histogram using said average intensity matrix.

106. (Original) The apparatus of claim 104, wherein the set of images forms a moving image.

107-110. (Cancelled)

111. (Original) The apparatus of claim 104, wherein said plurality of localized functions comprises a first localized function, a second localized function and a third localized function.

112. (Original) The apparatus of claim 104, further comprising electronic-calculation functionality for performing at least one morphological operation on said at least one binary matrix.

113. (Original) The apparatus of claim 104, further comprising a preprocessing unit for performing at least one preprocessing operation on the set of images.

114. (Original) The apparatus of claim 113, wherein said preprocessing unit is operable to remove clutter from at least one image of the set of images.

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115. (Original) The apparatus of claim 104, wherein said clustering unit comprises an origin definer for defining, for each region of the at least one region, an origin of the grid, said origin being defined as a central picture-element of said region.

116-125. (Cancelled)

126. (Previously Presented) The method of claim 1, wherein the image comprises an ultrasound image.

127. (Previously Presented) The method of claim 40, wherein the set of images comprises a set of ultrasound images.

128. (Previously Presented) The apparatus of claim 63, wherein the image comprises an ultrasound image.

129. (Previously Presented) The apparatus of claim 104, wherein the set of images comprises a set of ultrasound images.